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An ecological study of the Virginia rail (Rallus limicola limicola) and the sora (Porzana carolina) in some Connecticut swamps, 1947 ...

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AN ECOLOGICAL STUDY OF THE VIRGINIA RAIL (*RALLUS LIMICOLA LIMICOLA*) AND THE SORA (*PORZANA CAROLINA*) IN SOME CONNECTICUT SWAMPS, 1947

by

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INTRODUCTION

Rail have been neglected in the literature of the past as compared to the waterfowl and shorebirds. This neglect possibly stems from a lack of economic importance, coupled with the secretive nature of the birds. The following thesis is an attempt to summarize some of the major points in the life history of rail and to disclose some notes on rail habitat in Connecticut.

Rail, as described by Peterson (1947), are plump, somewhat chickenlike marsh birds of secretive habits, shy rather than wary, and much more often heard than seen.

The rails found in Connecticut are the sora (Porzana carolina), and the Virginia rail (Rallus limicola limicola) with which we are concerned here, the clapper rail (R. crepitans crepitans) a salt marsh dweller, the king rail (R. elegans), the yellow rail (Coturnicops noveboracensis), and the black rail (Cricicus jamaicensis stoddardi).

The following field marks distinguish the Virginia rail: Nine to 10.5 inches; a small reddish rail, with gray cheeks and a long, slightly decurved bill; the only small rail, near size of bob-white, with a slender bill. (Peterson, 1947).

The breeding range extends from southern British Columbia, Saskatchewan, southern Ontario, southern Quebec, Nova Scotia, and New Brunswick south to northern Lower California, Utah, Colorado, Nebraska, Missouri, southern Illinois, southern Ohio,

Kentucky, New Jersey, and eastern North Carolina; also in the Toluca Valley, Mexico. The winter range extends from Utah and Colorado (casually Montana) to southern Lower California, Guatemala, and the lower Mississippi Valley states, and from North Carolina (casually to Massachusetts) to Florida. This bird also occurs casually north to Hudson Bay, Labrador, New Foundland, and Greenland; also in Bermuda and Cuba. (Closely allied races occur in South America.) (A.O.U., Check list, 1931.)

The sora is a small, plump, gray-brown rail with a black patch on the face and throat, and a short yellow bill (Peterson, 1947). Its breeding range extends from Central British Columbia, Southern Mackenzia, Saskatchewan, Manitoba, the lower St. Lawrence River, New Brunswick and Nova Scotia, south to Northern Lower California, Utah, Colorado, Kansas, southern Illinois, northern Missouri, southern Ohio, Pennsylvania, and Maryland. The bird winters from California, Arizona, Texas, Florida through the West Indies and Central America to Venezuela and Peru. It is occasional in Labrador and New Foundland; accidental in Greenland, England, Wales and Scotland. (A.O.U., Check list, 1931.)

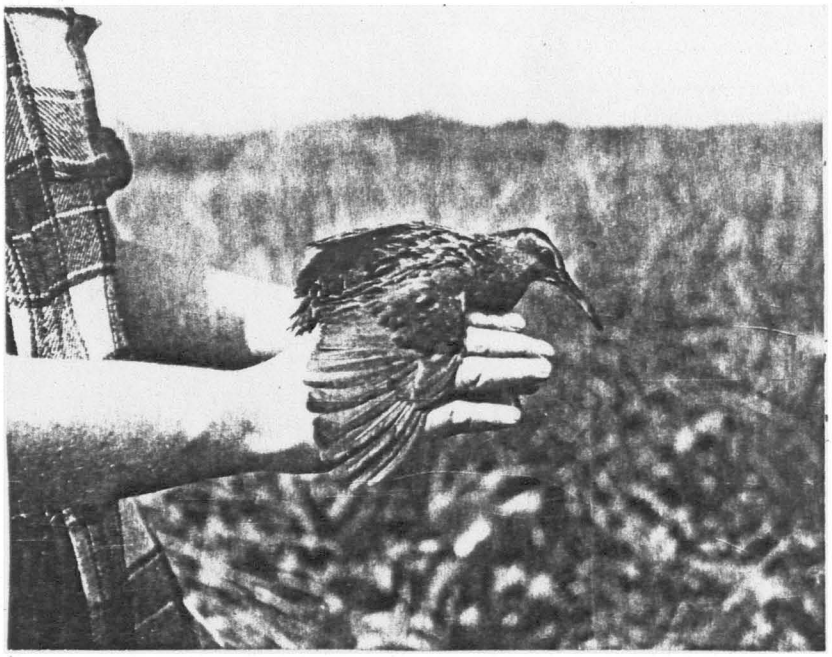

Fig. 1. Adult Virginia rail

METHODS OF STUDY

Although rail are frequently described as marsh dwellers, there is little information available to indicate how wide a tolerance these birds have to varied swamp conditions or what type of swamp is most heavily used by them for breeding purposes. Thus, the selection of study areas was centered in a survey of as many open swamps as possible, observing first those from which rail had previously been reported. Those swamps revealing rail after a period of listening and wading were tabulated and from that list a study area for each swamp type was chosen. To this list were added some swamps which were altered by natural or unnatural conditions, such as extensive flooding or pollution, which might add some interesting data to the study.

The complete list of study areas included the following swamp types:

1. A pond marsh; through the summer the water level of this marsh was expected to recede.

2. A river swamp; the water level of this type was expected to remain constant.

3. A swamp reflecting the fluctuations of the Connecticut River.

4. A shallow, firm bottomed river swamp.

5. A swamp containing wild rice (Zizania aquatica).

6. A polluted area.

7. A salt marsh.

The study areas were checked for nesting territories. The most thorough and accurate method for nest hunting was judged to be a search of the complete area, crossing it at intervals of no more than three yards.

The location and number of each nest was entered on a sketch map. The measurements of the nest and eggs were taken and the nest site was marked by a string placed where it would be conspicuous to the observer only.

A search of portions of the swamp from which calling birds were repeatedly heard generally disclosed a nest. Though this method is not recommended when the area studied is to be used as a basis of comparison for other swamp types, a reasonably accurate census or comparative census can be made by noting the number of calling birds. The value of this censusing method begins to decrease early in June.

The nests were checked bi-weekly, at least, until after incubation. A weekly check of broods followed until mid-August. The general location and cover type of the nest sites were taken and the distance between the nests was recorded in many cases.

A trap was used to facilitate the study of broods as well as to gain some information concerning plummage changes and growth rates. Twenty-five birds were taken, banded and released. The trap operated on the assumption that rails would

try to work around an obstruction rather than attempt to fly or climb over it. A net 100 feet by three feet and of one inch mesh, held erect by forked poles placed at five yard intervals, was stretched through a typical section of swamp. At either end of this drift net a double funneled box of 1.5 inch hardware cloth was placed. The trap box was 36 inches by 54 inches with the funnels tapering in for 12 inches. The neck of these funnels was 1.5 inches and was adjustable. The two wings of each funnel were equal and parallel to each other at their apexes. The top was securely tied to the sides, except for the last six inches which were given a temporary binding. It was through that flap that all of the captives were removed. The trap was not baited and was checked twice daily. Apparently the success of the trap decreased after ten days in the same location. The net was moved every two weeks unless a steady catch was being taken. When not in use, the net was dropped in order that the rails would not become too familiar with it. Both under and over familiarity with the net seemed to affect the catch adversely.

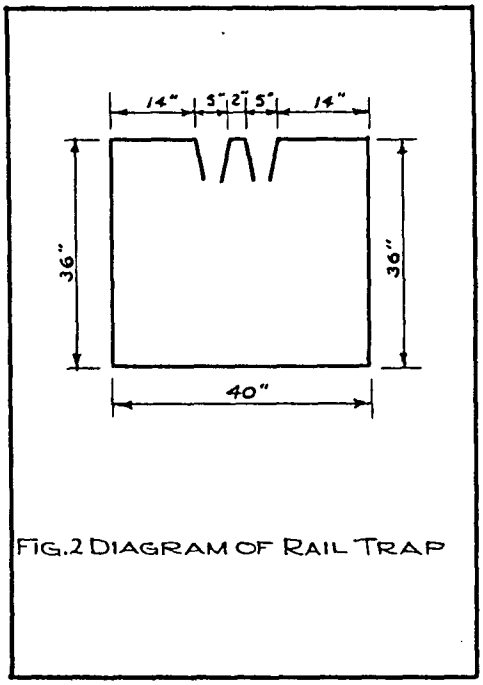

FIG. 2 DIAGRAM OF RAIL TRAP

On the basis of the conditions in the study areas, a survey for rail breeding areas was conducted. This survey was

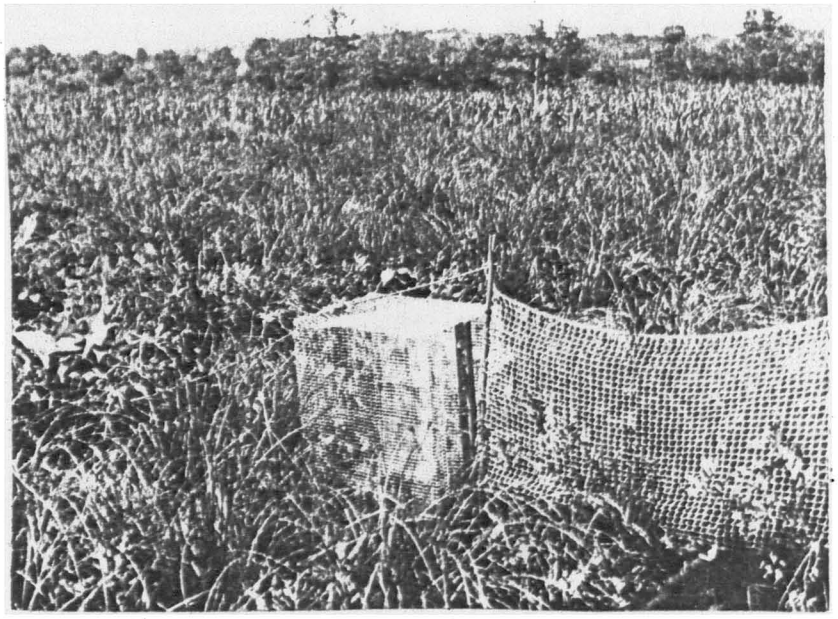

Fig. 3. Rail trap at Durham Meadows.

carried out with the aid of the State Game Wardens who pointed out the swamps in their districts; these were then evaluated as possible, fair, or good breeding areas.

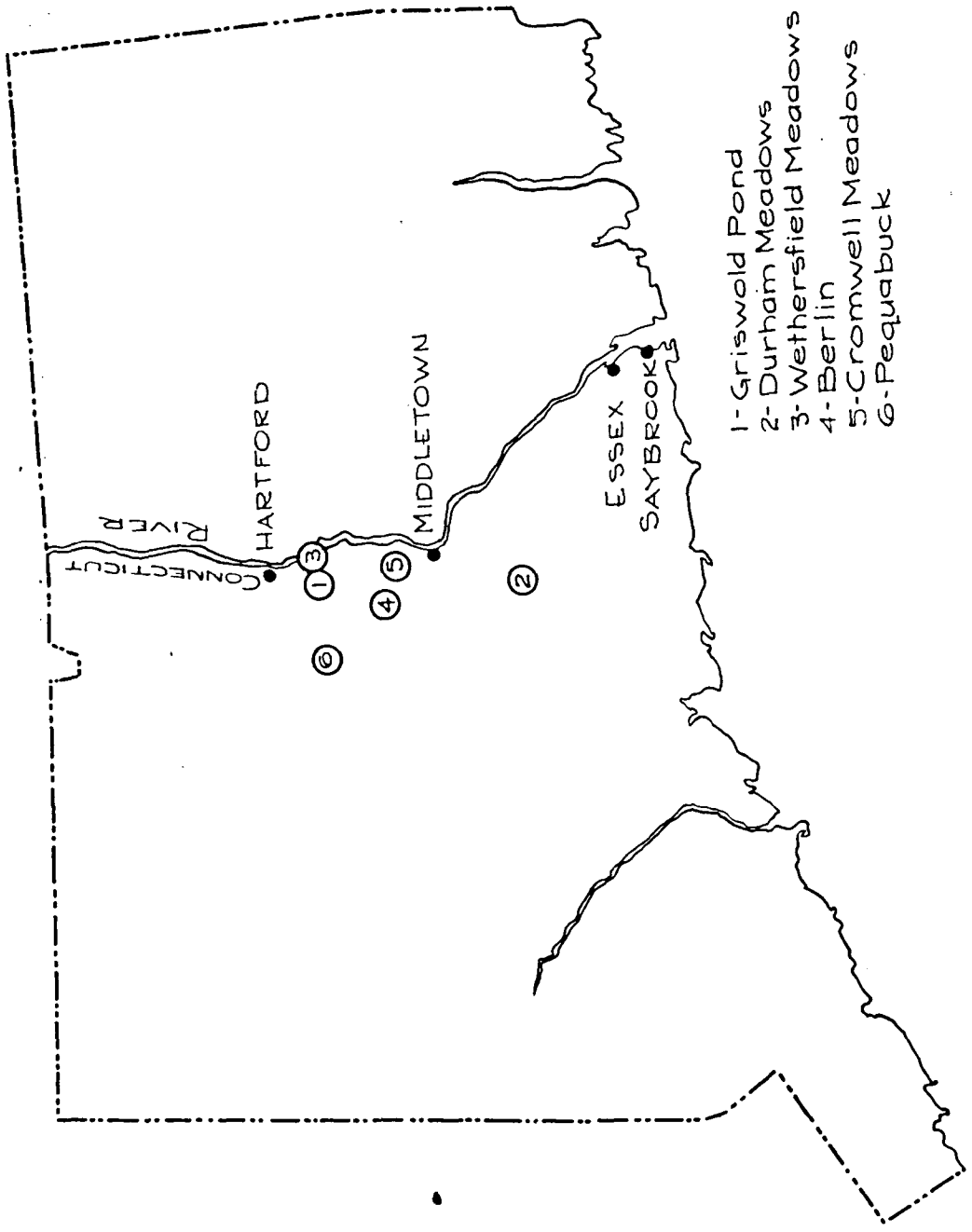

Fig. 34. MAP OF CONNECTICUT SHOWING LOCATION OF STUDY AREAS AND HUNTING GROUNDS.

THE STUDY AREA

Before describing nesting conditions in particular, it might be well to describe the areas on which nesting occurred. At first, to obtain a well-rounded picture of rail habitat, consideration of seven swamp types seemed advisable. These types included a pond marsh, a river swamp, a swamp influenced by flooding, a shallow firm bottomed swamp, a swamp containing wild rice, a polluted area and a salt marsh. The last type was eliminated since no good clapper rail swamp was found early enough in the season to warrant inclusion in this study.

Type I - Pond Marsh

Griswold Pond in Wethersfield, covering 20 acres, is a broad and narrow leaved cat-tail (Typha latifolia) and (T. angustifolia) swamp. The cat-tail roots have formed a mat two or three inches thick with from one to five inches of surface water. The water level below the mat varies between one and four feet. The bottom is a fine, firm mud. Although predominantly cat-tail there are, scattered throughout the area, small stands of soft stemmed bulrush (Juncus effusus), great bulrush (Scirpus validus), spike rush (Eleocharis sp.), reed (Phragmites communis), buttonbush (Cephalanthus sp.) and hummock sedge (Carex stricta). Most of these species also form an understory to the cat-tails. This cat-tail--rush--sedge as-

Fig. 4. Griswold Pond. Southwestern part showing cat-tails toward the center. Hummock sedges toward the shore.

Fig. 5. Griswold Pond showing reed grass and coarse sedges.

sociation borders both sides of the northern end of the pond leaving not more than 150 feet by 300 feet of open water. It was there, rather than at the southern part which has more hummocks, a greater open area and a narrower border of cat-tail, that most nests were found. Six acres at the northern end of this pond were used as a study area.

This spot was chosen as the area where the water level would slowly decrease throughout the summer. This held true as long as there was no precipitation, but a period of heavy rain could raise the level an inch or two. Excess water soon settled through the bog, thus keeping the water level constant. Less surface water was evident on the bog mat during July and August than was present in the spring; the loss was not more than two inches. The slight increases in water level during the nesting season were harmless, though an extended period of rain during incubation or the first two or three days after hatching might result in some loss of nests or chicks. There is perhaps more danger of destruction during long periods of dry weather which would afford better footing for predators.

Type II - River Swamp

Durham Meadows on the Cocinchaug River, a hummock sedge swale of 30 acres, was selected as the river swamp with a constant water level. A few scattered cat-tail patches and some brushy sections of buttonbush, alder (Alnus sp.) and swamp

maple (Acer rubrum,are found throughout the area. This swamp maple is invading the swamp from three or four points indicating that perhaps this swamp will be overgrown by maple in another 40 or 50 years. The hummock sedge reached a height of 3.5 to four feet by June 1. The culms when bent over by their own weight form excellent cover and render nest hunting, not to mention observation of broods, difficult. The water depth was between three and six inches; the mud at the bottom was from 16 to 20 inches. This fact was not apparent to the rail but was deeply so to the observer. By August the area was heavily overgrown with climbing hempweed Mikania scandens and Bidens sp. The study area at Durham comprised 5.5 acres of swamp.

Type III - Swamp Influenced by the Fluctuations of the Connecticut River

Swamps formed by flood waters of the Connecticut River are especially noticeable from Windsor to Middletown. A section of five acres at Wethersfield Meadows, which is a typical river-influenced swamp, was chosen almost at random. The swamp is formed by the water of the Connecticut River, which overflows its bank and backs into adjacent territory during the spring floods and slowly recedes throughout the summer until by August the water depth varies from zero to ten inches at the nesting sites. The area was not visited previous to June 9. The water was then 20 inches deep in the swamp and only 2 inches above the road, though earlier in the spring, according to the residents

of Wethersfield, the water had been two to three feet above the road. The flooding, which may have retarded the growth of protective cover in the spring, may have forced the birds to nest high in the grasses. These nests may have been more conspicuous and thus more subject to predation from above. The subsequent drop in water level may leave some nests over dry ground increasing the possibilities of predation from below. Thus, in these flooded swamps there appears to be a two-fold danger from predation; from above, since the nests are built toward the top of the old vegetation where new growth is slow to rise above them, and from below since some nests may be approached on dry ground. The amount of flooding of the Connecticut River probably influenced the number of breeding birds which used these flooded swamps, as well as affecting the success of those nesting birds.

The vegetation on the area consisted mainly of Reed Canary grass (Phalarus arundinacea), with some sweet flag (Acorus Calamus), bur-reed (Sparganium sp.) and cat-tail.

Type IV - Firm Bottomed, Shallow Swamp

Three acres of a small river swamp at Berlin were selected as Type IV. The study area is composed of three separate associations, broad leaved cat-tail, hummock sedges, and brush buttonbush, alder, and swamp maple. These associations are quite distinct with little overlap. Most of the

overlapping occurs between the brush and hummock sedges. The bottom throughout most of the area is firm, covered with a fairly constant water depth of five to ten inches. Along the stream, which meanders through the area, the bottom becomes muddy and the water depth increases rather suddenly to three or even four feet. The only nests found on this area were located within ten feet of this stream.

The cat-tails, which were favored by the American bittern (Botaurus lentiginosus) and were heavily used by the redwing (Agelaius phoeniceus) toward evening, offered good protective cover. The water level of four to five inches coupled with a firm bottom apparently made this portion unsuitable to rail, for no birds were heard among those cat-tails.

Type V - Area Containing Wild Rice

Cromwell Meadows, as most of the areas in Connecticut which produce wild rice, is flooded during the spring and also has a slight tidal effect. At the time of nesting, the flood water had completely inundated the area, and by the time the water had receded and the vegetation had advanced to a suitable height for nesting, the nesting season was well under way. By June 15 the water had dropped at least six feet below the level of April 19. A second short flood occurred within that period however.

In addition to the wild rice, arrowhead (Sagittaria lati-

folia), arrow arum (Peltandra virginica), sweet flag, horsetail (Equisetum sp.), buttonbush and bulrush (Scirpus sp.) are found in some profusion. The bottom is muddy and the water depth is variable, making the area practically inaccessible for rail hunting. Some areas can be covered on foot, others by boat, but the major part of the area consists of a combination of deep water, muddy bottom, and thick vegetation, which makes navigation difficult.

Six acres of the 80 acre tract were covered during the nesting season, though a considerably larger portion was examined late in the summer and early in the fall.

Type VI - Polluted Area

The polluted area chosen is on the Pequabuck River at Farmington. This swamp, covering 20 acres, offers a wide variety of cover types including some which should be excellent rail cover. A range of water depth from two or three inches to three or four feet and conditions simulating those of Types I, II and even III, would lead one to expect a small rail population at least. The area is heavily polluted, receiving waste products from many of the factories in Plainville and Bristol. Five acres of this study area were visited weekly during May and June and three trips through the entire area were undertaken.

THE VIRGINIA RAIL

Arrival and Behavior

The first arrivals reached the areas under consideration about April 20, but major part of the migration arrived early in May, The new growth of cat-tails and sedges had scarcely begun and offered little protective cover, but enough of the previous year's vegetation was left standing to provide adequate protection.

During the spring, while the cover was limited, the birds were much more easily flushed than they were later when the vegetation had advanced. When seen in the open the birds showed a singular lack of concern and stalked about with an elaborate show of nonchalance. They did not appear to be frightened, but apparently preferred to remain in the protective screen of cat-tails and sedges when possible.

In the hand little or no fear was shown, in most cases. An occasional bird would cry and struggle exhibiting a powerful enough wing stroke, but most birds were relaxed, calm, and deliberate, particularly in their attempts to peck the hand of their captor.

Calls

The spring song, or call more properly, was a dry, rather metallic "cut cut cut cutta cut." This call is peculiar to

Fig. 6. Virginia rail at home.

the male and is no doubt his love call (Brewster, 1902). More commonly heard during the spring, summer, and even in September on one occasion, was the pig-like grunt. This call was most often uttered when the nest was approached and may have been used when the nest site was approached too closely. It was assumed that both sexes gave this call. In September this grunt was once evoked in response to a gunshot. The fall call was more commonly a sharp "Keep" given in response to a paddle slap, gunshot, or the splash of a rock. Several birds generally responded to the splash or shot; their calls were echoed by other birds in that vicinity. From those calls an indication of the number of fall birds present could be gained.

The alarm note was generally a harsh "Skeep" similar to the fall call. Also to be heard was a "Kidic kidic kidic" reported by Walkinshaw (1937) as a scatter call.

Nest Construction

Nest construction, on the areas considered, began early in May when the hummock sedge had reached 14 to 16 inches and the cat-tails were scarcely two feet tall. The nests were composed largely of material that was found near at hand. The materials most commonly used were cat-tail, grass, hummock sedge or one of the many coarser sedges, such as Carex rostrata and Carex lurida. If finer material, as Eleocharis sp. was found nearby, the nest might be lined. The nest was a woven basket

with the foundation generally resting on or within an inch of the hummock or cat-tail clump on which it was built. In most cases a ramp or runway, composed of materials similar to those which formed the body of the nest, was present. The ramp was rarely more than a foot long and was generally narrow, less than two inches across and of uniform width, though an occasional one might flare at the base as was more typical of the ramps of sora nests. In general, a canopy of surrounding vegetation was pulled down to cover the nest. This canopy was loosely woven and generally formed of surrounding vegetation, but an occasional canopy formed of the previous years' vegetation, which had been pushed up by new growth, was found. The average inside depth, as based on measurements of 30 nests, was 1.75 inches though the variants were three inches and .75 inches. The outside depth, from the rim to the water, varied from 5 to 10 inches, averaging 6.40 inches as based on measurements of 17 nests. The average size of the nest bowl of 26 nests was 4.60 inches by 4.5 inches. The water depth, surrounding the nest site, fluctuated with rainfall, but rarely exceeded six inches and commonly remained near 2.60 inches during the early stages of incubation.

Nest Location

Of the 24 nests which contained eggs, nine were built on hummocks, six were found among the cat-tails and coarse sedges, six were built in reed canary grass, two in the coarse sedges,

and one was located in cat-tails. Considering the 45 nests found, including those containing neither eggs nor shell fragments, 20 were built on hummocks, 13 in coarse sedges and cat-tails, six in grass, two in coarse sedges, and two in the soft stemmed rush.

From observations in the field concerning the conditions of nests, the cat-tail-coarse sedge association was judged to be most favorable to nesting Virginia rails.

Many nests, apparently unused but built after the arrival of the birds, were located. These nests were often found close

Table 1. Relation of Vegetative Types to Number of Nests Found

Plant Association	Acreage	No. Nests Containing Eggs	Total No. Nests
Hummock sedge	9	9	20
Cat-tail-coarse sedges	4	6	13
Reed Canary Grass	5	6	6
Cat-tail	2	1	2
Coarse Sedges	$1\frac{+}{-}$	2	2
Soft Stemmed Bulrush	$\frac{1}{2}\frac{+}{-}$	-	2

to "active nests", that is, nests containing eggs or shell fragments. The grouping of these inactive nests and, in many cases, the distance to the nearest active nest was noted. It is doubtful that these empty nests were entirely due to predation and in most instances they were considered as trial or

practice nests. While considering inactive or empty nests, however, the following nest history should not be overlooked. This empty nest was found on May 16, held one egg May 17, two eggs May 19, two eggs May 20, and neither eggs nor shell fragments May 22. This would appear to indicate desertion followed by destruction. Since no shell fragments were found, and since a banded water snake (Tropidonotus fasciatus) had been seen in the immediate vicinity, the predator was judged to have been reptilian. The nearest active nest in this case was 25 feet away. The history of this nest is included here, for had it been located six days later, it would have been classed as inactive. Despite the evidence offered by the aforementioned nest, the conditions appeared to indicate that these empty nests were more frequently practice or trial nesting attempts.

On one section 30 feet by 80 feet, 12 nests were located. Two of these contained shell fragments and one brood was known to inhabit the section.

The following chart will show the relation of these nests to each other, while Table 2 shows the distance between the nests.

Table 2. Distances Between the Nests in the Nest Concentration of Durham

Nest No.	No. Feet	Nest No.	No. Feet	Nest No.	No. Feet
11-12	20	19-20	13.6	22-18	20.4
11-17	23	19-21	16	22-23	17
12-17	23.6	20-21	2.5	23-24	23
18-17	49	21-18	11.4		

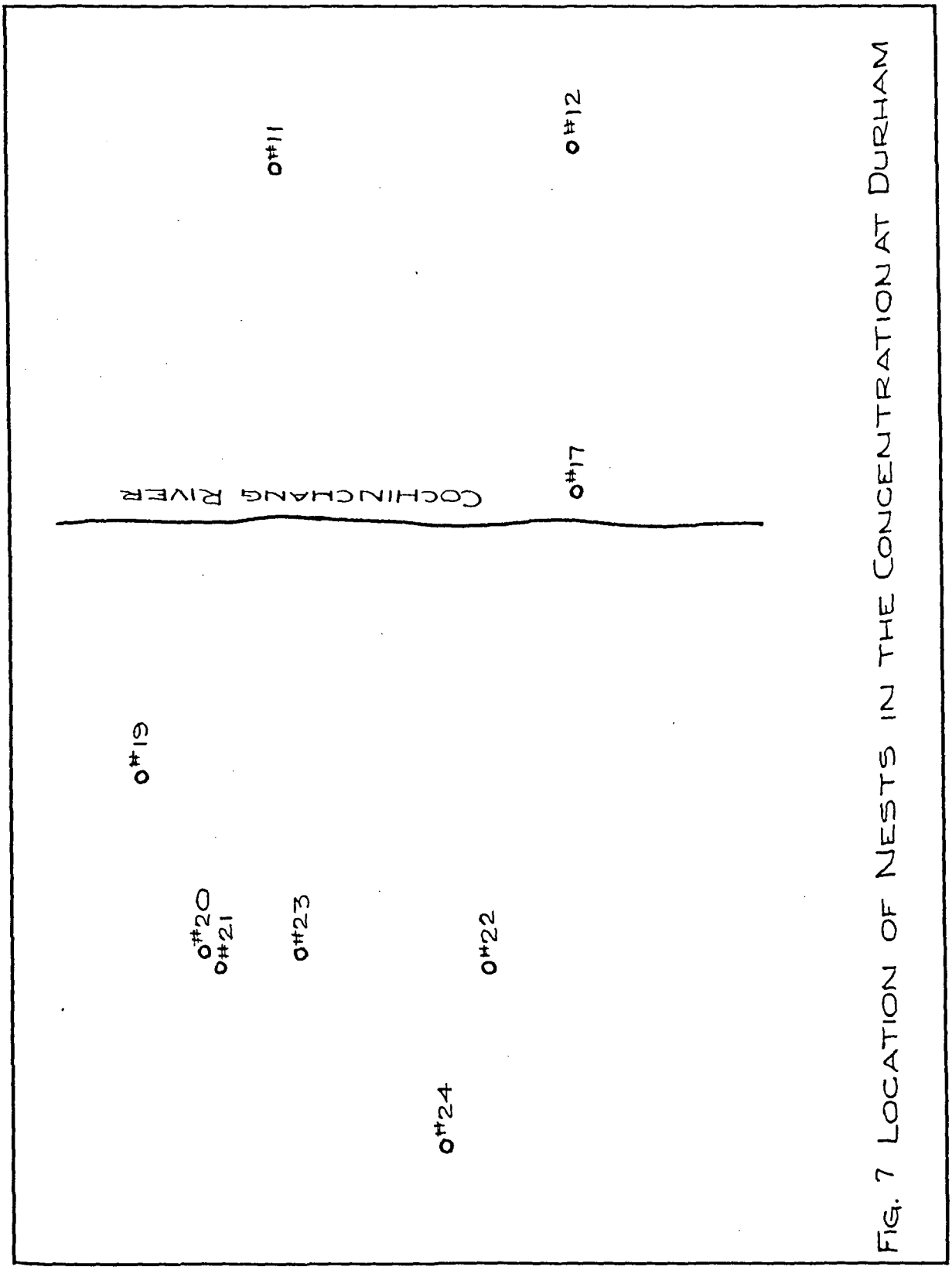

FIG. 7 LOCATION OF NESTS IN THE CONCENTRATION AT DURHAM

This concentration was probably the work of two birds, as nests 11 and 22 contained shell fragments which were typical of fragments found in nests that had successfully hatched. The eight other nests were classed as practice nests.

The construction of these inactive nests was, in general, similar to that of the active nests found in the study area, although in some cases the inactive nests appeared to be woven more loosely and to lack the canopy which was found on most of the active nests.

The distance between another empty nest and the nearest active nest was 43 feet. Distances between nests containing eggs were considerably varied, revealing a minimum of 132 feet for this year and these conditions.

Table 3. Distances Between Some of the Closer Active Nests

Nest Number	Distances in Feet
30-38	132
14-16	227
1-14	144

Table 4. Survey of Breeding Populations for Each of the Study Areas*

Swamp Type	Nest With Complete Clutches	Estimated Birds	Acreage
Type I. Pond marsh with slowly decreasing water level cat-tail	9	11 pr.	6
Type II. River marsh with stationary water level hummocks	5	7-8 pr.	5½
Type III. Swamp reflecting fluctuations of Connecticut River	4-2 renests	6 pr.	5
Type IV. Firm bottomed shallow swamp	2	3 pr.	3
Type V. Swamp containing wild rice.	0	2 pr.	6
Type VI. Polluted area	0	0	?

*These estimates were based on nests found and the number of areas from which calling birds were heard.

Renesting

Evidence of renesting was found on several occasions. Renests were judged by the late hatching date and the proximity to destroyed nests.

Table 5. Distances Between Destroyed Nests and the Nearest Successful Nests

Number of the Destroyed Nest	Number of the Possible Renest	Distance in Feet
41	42	36
46	47	62
2	38	25
2	30	46

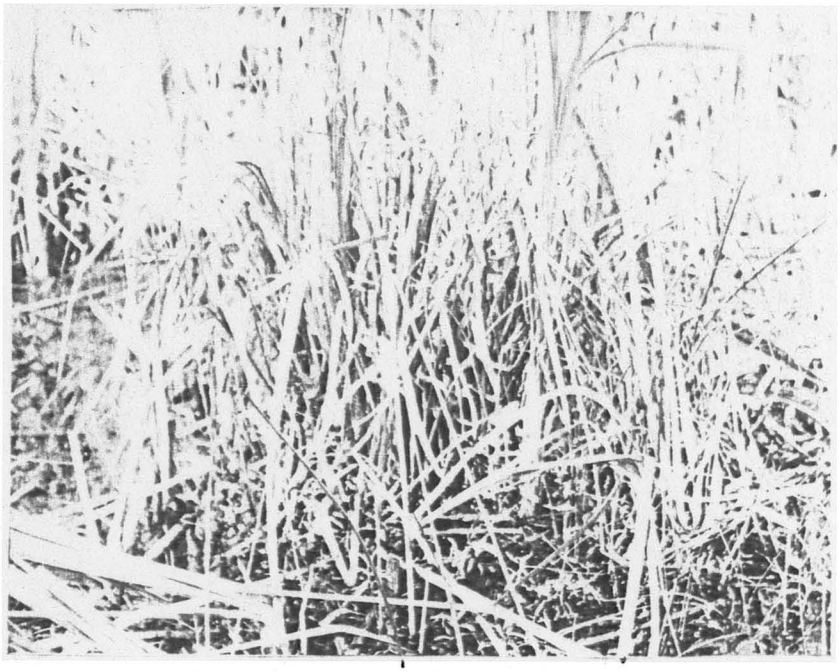

Fig. 8. Clump of cat-tail and coarse sedge in which a Virginia rail nest was hidden.

The egg laying in the renests, for nests 41 and 46, was begun June 11 and 13 respectively. No evidence of later renesting was found. Walkinshaw (1937) reported one nest with seven eggs which hatched August 2 and 3. Assuming the incubation after the last egg was laid to have been 18 days, this clutch would have been begun July 10.

Eggs

The eggs of the Virginia rail were white or buffy white with tan or reddish brown and purple speckling generally concentrated toward the larger end. The speckling may occur over the entire surface of the egg and in one case was found conconcentrated at the smaller end. In all cases the speckling was fine, not blotched, as was typical of the marking on sora eggs.

The average size of 162 eggs measured was 31.49 mm x 23.9 mm. The maximum width was 25.5 mm, the minimum width 22.0 mm. The maximum length was 35.4 mm, the minimum length 28.3 mm. The variation which may occur in a clutch is shown in the following chart.

The average clutch size on the study areas, as based on 15 clutches considered to have been completed, was 9.33 eggs. Some variation of the clutch size existed on the individual study areas. The nine nests at Griswold Pond were most productive averaging 9.66 eggs per clutch; Durham followed with an

Fig. 9. Virginia rail nest. Note the narrow ramp in the center of the picture.

Table 6. Range of Egg Size in a Single Clutch in Millimeters

Nest	Clutch Size	Max. Egg Length & Width	Min. Egg Length & Width	Max. Egg Width & Length	Min. Egg Width and Length
1	11	---	---	---	---
3	9	32.9x25.2	30.0x24.4	30.4x25.5	31.4x23.5
5	10	---	---	---	---
7	10	30.1x23.9	28.3x23.7	29.6x23.9 30.1x23.9	29.2x23.4
8	9	31.3x23.0	29.7x24.5	30.8x24.8 29.9x24.8	31.3x23.0
9	10	33.5x23.6	32.4x23.5	32.9x23.7	31.9x22.0
14	9	32.3x24.0	30.1x24.8	31.3x24.9	32.3x24.0
15.	10	32.8x23.4	29.2x23.4	32.7x24.6	29.2x23.4
16	11	30.5x23.8	29.0x22.6	29.8x24.0	29.0x22.6
30	9	33.2x24.1	31.5x22.8	32.8x24.5	31.5x22.8
28	8	32.7x23.4	30.5x23.6	31.4x23.9	31.4x22.7
39	7	35.4x24.3	33.3x24.1	35.3x24.3 35.4x24.3	35.0x24.0 33.7x24.0
42	9	33.3x24.6	31.9x24.7	33.2x25.3	32.3x24.0
43	9	35.4x24.3	31.4x22.7	33.8x24.5	31.4x22.7
47	9	32.8x24.1	31.1x23.8	32.8x24.1	32.3x23.2

average of 9.50 eggs for two nests, while the average of four nests at Wethersfield Meadows was 8.50 eggs per clutch.

Unless the observer arrived just as the chick was emerging from the egg, he would only rarely find any trace of the hatched shells in or near the nest. It was believed that the shells were removed from the nest by the adult shortly after the

chicks had hatched. In three instances the egg membrane was found in or near the nest. Thus there exists the possibility that the adult ate the shell for the calcium which it contained, though the possibility of mouse activity can not be ignored. On another occasion four empty shells were present in a nest. The adult was found in the rail trap, which was located within 50 feet of the nest, and this may have accounted for the accumulation of egg shells. Under ordinary circumstances a nest which had hatched successfully contained small fragments of shell ground into the bottom of the nest.

Incubation, Nesting Period and Egg Success

Walkinshaw (1937) reported the incubation time to be 20 days starting, in a majority of cases, the day before the last egg was laid. Wood (1937) also reported the incubation period to be 20 days, while Mousley (1940) believed the incubation period to be 18 days from the laying of the last egg.

The following figures, which are inserted to form a groundwork for an estimate of incubation time, indicate that one egg was laid daily during the latter part of the laying period, although skips were found early in the season.

Nest 1. Found at 9:30 a.m. on May 17, with four eggs, five eggs at 11:45 a.m. on May 17; 7 eggs May 19; eight eggs May 20; 10 eggs May 22; 11 eggs May 24; one egg laid per day.

Nest 2. Empty May 16; one egg May 17; two eggs May 19;

Fig. 10. Virginia rail incubating.

two eggs May 20. In one case one egg was laid per day though the total shows five days and two eggs. The nest was judged to have been subject to desertion and predation.

Nest 3. One egg May 19; one egg found in the rail trap located within fifty feet of the nest was added May 19; three eggs May 21; five eggs May 23; eight eggs May 26; nine eggs May 31. From May 23, through 26, one egg was laid per day. A skip occurred early in the laying period.

Nest 8. Six eggs May 22; eight eggs May 24 a.m.; nine eggs May 24 p.m.; three eggs apparently laid in two days. Probably the seventh egg was laid on May 22 after the nest was found. It may be safe to assume one egg per day.

Nest 9. Five eggs May 22; seven eggs May 24; eight eggs May 25; ten eggs June 2. From May 22 through 25, one egg was laid per day.

Nest 10. Nest found empty May 22; one egg May 23; destroyed May 28. Meager evidence of one egg per day.

Nest 14. One egg May 24; two eggs May 25; nine eggs June 2. In one case one egg was laid per day. Total nine eggs in ten days, but had the nest been checked between May 25 and June 2 the result might well have been one egg per day.

Nest 39. Five eggs June 16; six eggs June 17; seven eggs June 18. One egg was laid per day.

Nest 42. Seven eggs June 17; eight eggs June 18; nine eggs June 20. In one case one egg was laid per day. Total two eggs laid in three days. Possibly one egg per day.

Nest 43. Seven eggs June 17; eight eggs June 18; nine eggs June 20. Meager evidence of one egg per day. Assuming then that one egg was laid per day, the date the last egg was deposited has been determined. Using that date, the period of incubation from the day after the last egg was laid was calculated. From the data gathered, it would appear that the eggs were deposited at any hour of the day, for addition of eggs was noted between ten and twelve a.m. and between three and six p.m.

Table 7. Days of Incubation Following the Deposition of the Last Egg

Nest	Days of Incubation Following the Deposition of the Last Egg	Probable Incubation Time*
1	18	20
3	16-18	18-20
8	18-19	20-21
9	17-18	19-20
14	16-18	18-20
42	16-18	18-20

*Obtained by adding two days to the number of days of incubation following the deposition of the last egg. This addition is felt to be permissible since the hatching of one egg a day later than the others of the clutch indicated that incubation may have begun the day before the laying of the last egg.

The fact that, in most cases, one egg was found to hatch a day later than the others of the clutch helps to substantiate the statement of Walkingshaw (1937) that incubation is begun the day before the last egg was laid.

The egg success as determined from 15 nests or 139 eggs showed only six eggs which failed to hatch. Four of these were found at Wethersfield Meadows, two at Griswold Pond. Five of the six deserted or unhatched eggs were found in late nesting, possibly renesting attempts, and three of those five were found in a single nest. The effect of adverse conditions may have a severe effect on the survival potential, if these figures can be considered as a true indication of the egg success of late nesting or renesting attempts.

The nesting period, considering all study areas, was 63 days. The first egg was estimated to have been laid on May 8, the last was hatched on July 9. The date of hatching varied considerably on the three swamps where larger concentrations of birds were found. Unfortunately the figures concerning the initiation of nesting activity in two of these swamps were not complete. However, the date of hatching, which may reflect a later commencement of nesting activity, is available and shows some variation. The nests at Durham, the constant water level-humock sedge swale, hatched over a period of 23 days. Behavior of adults indicated the presence of a brood as early as May 23, while the last known nest hatched June 14. At Griswold Pond, the cat-tail marsh, hatching extended for 13 days. The first nest had completed hatching on June 8, the last on June 20. No explanation for this discrepancy has been formed at this time. Griswold Pond was rated as a superior breeding area because of the number of birds utilizing it, the

larger size of clutches, the vegetative type, and the water depth. Durham is 20 miles south, though not as close to the Connecticut River Valley, and was rated as a good breeding area. The duration of the hatching period at Wethersfield Meadows, the swamp directly influenced by the Connecticut River, was ten days. The first nest hatched June 30, the last July 9. Since this study area was not examined until June 9 there was a possibility that some earlier hatchings might have been overlooked. Neither broods nor nests showing evidence of hatching were found. The flooding of the Connecticut River and the high predation rate were considered to be important factors in the later hatching dates of these nests.

Table 8. Hatching Dates in Three Different Study Areas

Durham	Griswold Pond	Wethersfield Meadows
May 23*	June 8	June 30
May 26*	June 10	July 6
June 3	June 11	July 7
June 4	June 12	July 9
June 6*	June 14	
June 14	June 14	
	June 18	
	June 18	
	June 20	

*Nest not found, but adults were exhibiting behavior which indicated a brood only two or three days old was close by.

Behavior of Adults

The adults did not appear to go far from the nest, even during the early part of the incubation period, and were often

heard grunting or scolding from the vicinity of the nest. This factor was a distinct advantage in nest hunting and would also be a valuable aid in censusing the birds in the spring.

In general, birds surprised on the nest quickly leaped to the water and disappeared among the cat-tails and sedges. One bird, however, was flushed directly from the nest on three separate occasions. The distance of flight in each case was about 15 feet. Toward the end of the incubation period the birds became more distressed at intrusion and tended to remain in sight uttering shrill cries. The broken wing act was occasionally observed at this time, but more often one or both wings were spread showing the chestnut coverts to best advantage as the bird advanced dipping its head. Some birds folded their wings tent-like over their backs and moved rapidly about their nest.

Other birds, though, defended their nests by direct attack. One bird flew at the observer, covering the intervening three feet with astounding rapidity, pecked the hand extended toward the nest and had withdrawn before the portent of the bird's activity was realized. A second, surprised on the nest, nipped the hand of the observer as the canopy was being pushed aside. After the attack the bird splashed into the water and disappeared behind a hummock from whence she continued to call. The third bird defended her nest calmly and deliberately. Little effort was spent in displaying or in attempts to lead the intruder away, but each motion toward the eggs was greeted with a peck

Fig. 11. Virginia rail defending her nest.

Fig. 12. Virginia rail defending the nest.

from her bill, which she was able to use with deadly accuracy. The peck, though not strong enough to draw blood from a human hand, was probably formidable enough to make most predators hesitate before attempting to destroy the nest.

Juveniles

At the time of hatching the chicks emerged covered with wet, matted, black down which was dusted with white flakes. After a few hours, when the down had dried and the white flakes had worn off, the chick attained a greenish-black sheen. The bill was a pinkish ivory with a black band encircling it near the tip and had a white egg tooth evident on the maxilla. The legs were gray with a pinkish undercast. A claw a millimeter long was present at the bend of the wing. The eye was black.

These newly hatched chicks were found to be relatively inactive during their first twelve hours of life. A newly hatched chick, placed on open water, slowly sank, even though it attempted to support itself on the water by spreading its wings. These chicks were found more readily during the first two or three days after hatching and were often caught in the rushes and sedges which were tangled on the surface of the water.

A week old juvenile taken in the trap was found to be sturdy and active, capable of swift movement among the hummocks. The bill was 9.5 mm long.

At three weeks the down was still present, though the feathers were beginning to appear on the belly, legs and back. Two rows of buff feathers could be seen on the belly, the legs were streaked with buff and the feathers appearing on the back were brown. These colors were not apparent at a cursory glance, for the chick was still downy with a rich, green-black sheen. The feathers, to which the down was still attached, were scarcely a millimeter long and were noticed only during a close examination. The eye was black. This description of the three week chicks was based on two observations and variations from it may be expected.

At four to five weeks the general impression gained was that of a dark bird with chestnut coverts and lighter under parts. The crown was black, with down still present. A gray line, darker above than below, ran through the eye. The lower eyelid was white. The primaries were black, sheathed more than onehalf of their length and with down still adhering to them. The coverts were chestnut brown. The underwing was largely quill, but gave an impression of gray and white. The back and secondaries were black margined with olive brown, which gave a streaked appearance. The feathers of the sides of the breast were black, tipped with chestnut. The chin and throat were white and a white line, occasionally lightly speckled with black, extended to the belly. The tail feathers were black, the under tail coverts barred orange buff, white and black. The sides, flanks and belly were black and white

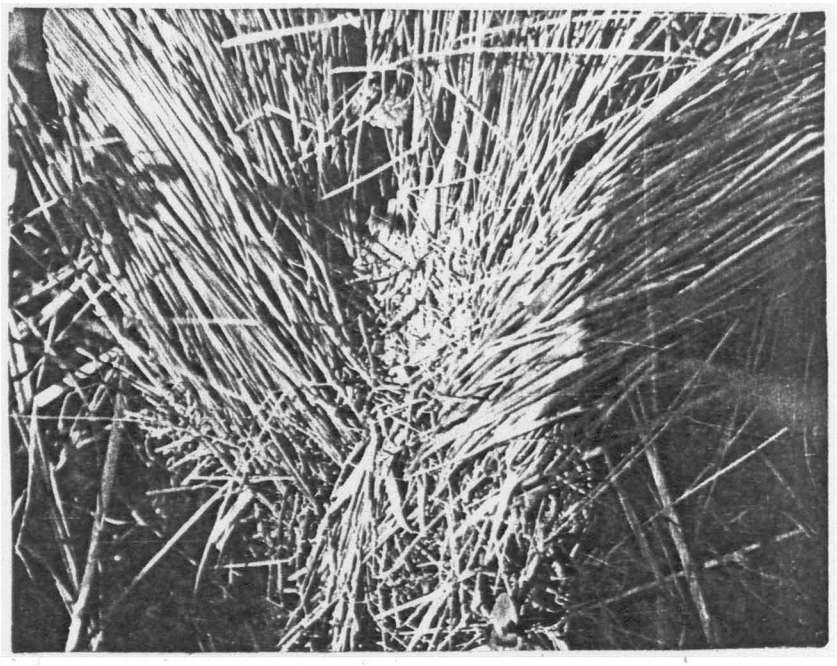

Fig. 13. Hatched nest. Fragments of egg shell are ground into the bottom.

and were beginning to assume the characteristic striped appearance of the adult. The feathers of the legs were dark, tipped with fawn, and appeared to be speckled. The rump was still in down. The iris was olive brown. The bill was black, becoming a pale orange at the base of the mandible. The tip of the maxilla was often lighter. The bill of one bird was 29.8 millimeters. The legs were black with a pinkish cast.

At six to seven weeks the general impression was similar, though the following changes were noted. The primaries were sheathed less than one-third of their length. The crown was black, flecked with orange buff. The bill was black above, while the orange on the mandible had become more pronounced. The leading edge of the wing was white, as was the outermost margin of the first primary. A buff line above the lores, becoming more gray over the eye, was evident. The eye ring encircled three-quarters of the eye, the forward quarter of the upper eyelid lacked the white color. The rump was gray black. The bill of one bird of this age class was 31.9 mm. Birds of this age were able to fly short distances.

By ten to 12 weeks the eye ring appeared to be more distinct, though it still encircled but three-quarters of the eye.* The mandible had become a deeper orange, the maxilla was black. The iris showed the first signs of turning red, particularly at the outer edges, though a greenish brown cast could still be seen. The jaw line was buff. The rump was similar in color to the rest of the back.

At 14 weeks, about the second week in September, evidence of a fall molt was present. The breast was becoming rufous and quills were noted on the back, flanks, rump and breast. These quills had not advanced far enough for the color to be determined, but it was judged that the juveniles would emerge from the fall molt in adult plummage. Immature birds of September had bill lengths ranging from 33.9 mm to 40.0 mm.

There appeared to be some variation in color among the juveniles, particularly in the undertail coverts which varied from almost solid black to a rich orange buff depending upon the width of color on those feathers. There was also considerable variation in the white line which ran from the throat to the belly. This was occasionally separated at the throat by a dark band.

In general the juveniles resembled the adults except for the lack of a rufous breast, the darker primaries, the lighter mandible and the green-brown iris. The descriptions given above were taken from 15 birds: two four-to-five week birds, five of the six-to-seven week age class, three of the nine week class, and five September birds.

Behavior of Adults and Broods

Observation of broods was difficult, requiring time more than any other factor. However, since the broods remained close to their nesting territory for some time after hatching,

they could be checked by sound with some degree of accuracy. Newly hatched broods, containing two to three day old chicks, were the easiest to find. The adults appeared in the open calling shrilly, bowing, dipping and spreading their wings. In some cases, they appeared in the open calling shrilly but refrained from display, resorting rather to a seemingly studied carelessness as they pecked at the vegetation and probed in the mud. Evidently the calling was a warning for the young to stay hidden deep in the sedge clumps or cat-tails. By careful searching one or two of the less wary chicks of each brood were found. By the fourth or fifth day after hatching the adults ceased to appear in the open for extended periods, but limited their warning to the chicks and distraction of the intruder to shrill cries and a brief exposure of themselves. It often appeared that one adult had led the brood away, while the other adult remained hidden near the source of disturbance calling and showing itself for brief moments as it slipped about among the cat-tails and hummocks. The behavior was also observed by Walkinshaw (1937). An observer standing near the edge of the marsh may hear the broods splashing about and uttering a shrill whistled "pee-eep!"

The juveniles apparently remained together until the middle of August at least. On August 11 several broods were heard scampering through the swamp near former nest sites. During the third week in August the breeding grounds sounded comparatively empty, no groups of birds were heard and only an

occasional bird was heard when a gun was fired over the area.

On four occasions broods were thought to have been heard from the blueberry (Vaccinium sp.) and blackberry (Rubus sp.) patches which grew within fifty yards of the swamp margin, but no actual sight record substantiating this was obtained.

Molt

Only two molting adults were observed. The first of these was taken in the trap on July 24. Most of the primaries and secondaries were loose and many had already been lost. This bird was recaptured July 26 with neither primaries nor secondaries. The coverts alone remained on the wing. The second adult in molt was taken August 26 with the primaries sheathed one fourth of their length. No molting of the contour feathers was noted in either case, though undoubtedly such a molt should occur during this period.

On September 10 a molting juvenile was captured. Quills showed on the back, neck, flanks and breast. The feathers which appeared on the breast were the rufous red characteristic of the adults. The iris was still olive green, though red flecks indicating the change to the red eye color of the adult were evident. It was assumed that the immature birds would emerge from this molt in plummage similar to that of the adults.

Predation

Because of the relative inaccessibility and dense cover of the habitat, not to mention the secretive nature of the bird, the predators are limited. Forbush (1925) stated that most of the larger animals and birds of the marshes, from the sandhill crane down to the mink, devour the eggs and young rails whenever they find them. A list of predators would probably include the marsh hawk (Circus cyaneus hudsonius), red-shouldered hawk (Buteo lineatus), red-tailed hawk (Buteo jamaicensis), yellow billed cuckoo (Coccyzus americanus americanus), possibly crow (Corvus brachyrhynchos), and mink (Mustela vison).

At Griswold Pond one nest, as mentioned under the subheading of Nest Location, showed a loss of two eggs. The predator was judged to have been a water snake. Nest 7 showed a loss of four eggs; this loss was felt to have been the work of an egg collector. Durham showed no actual nest destruction, though on three occasions partially eaten eggs indicating avian predation were found. A single nest, which had been destroyed previous to the time of discovery, was found at Kensington. No renest was found and the birds were not heard upon subsequent visits to the swamp. This Kensington swamp was not classed as a study area because of its small size and similarity to Griswold Pond, but it was a valuable aid in the early part of the study since the first rails of the project were heard there. One nest was destroyed at Berlin. This

nest was built on a hummock which was easily accessible from one side though protected by a stream on the other. A red wing nest situated within ten feet of this nest wws also destroyed. The shell fragments were indicative of avian work. At Wethersfield Meadows five of seven nests were destroyed. The flooding of the Connecticut River which forced the birds to live in more exposed, less favorable cover was felt to have had considerable bearing on the high rate of predation. Avian predators, possibly the yellow billed cuckoo which nested on the area, were thought to have destroyed four of the five unsuccessful nests. The fifth was thought to have been the work of a mammal, possibly mink.

Nesting Associates

Those birds found nesting near the Virginia rail, though apparently not affecting them in any way, were the red-winged blackbird, swamp sparrow (Melospiza georgiana), long billed marsh wren (Telmatodytes palustris), short billed marsh wren (Cistothorus stellaris), black duck (Anas rubripes), American bittern, and eastern least bittern (Ixobrychus exilis exilis). A yellow billed cuckoo, which was accused of wreaking considerable havoc among the nesting rails on one study area, nested in a clump of willow trees situated in the swamp.

Table 9. Summary of Data on Virginia Rail Nesting Conditions

Nest Number	Study Area/	Cover Type at Nest Site	Date Found	Clutch Size	Date Clutch Was Begun *	Date Clutch Completed	Date Hatched	No. Eggs Not Hatched	Predation	Incubation x
1	G	Hummock sedge	10 May	11	12 May	23 May	10 June	1		18
2	G	Coarse sedge cat-tail	16 May		17 May				Reptilian	
3	D	Hummock sedge	19 May	9	18 May	27 May	14 June			16-18
4	K	Coarse sedge	19 May	7	12 May				Avian	
5	D	Hummock sedge	21 May	10	8 May	17 May	4 June			
6	D	Hummock sedge	21 May	7	8 May		3 June			
7	G	Coarse sedge	22 May	10	12 May	23 May	8 June			
8	G	Coarse sedge cat-tail	22 May	9	16 May	24 May	12 June			18-19
9	G	Cat-tail	22 May	10	23 May	27 May	14 June			17-18
10	B	Hummock sedge	23 May						Avian	
11	D	Hummock sedge cat-tail	23 May				on or before 23 May			
14	G	Cat-tail coarse sedge	24 May	9	24 May	1 June	18 June			16-18
15	G	Hummock sedge	27 May	10	18 May	27 May	14 June			
16	G	Coarse sedge cat-tail	27 May	11	14 May	24 May	11 June			
22	D	Hummock sedge					on or before 26 May			
27	B	Hummock sedge	30 May	8	7 May	14 May	1 June			
30	G	Coarse sedge cat-tail	4 June	9	25 May	2 June	20 June	1		
38	G	Coarse sedge cat-tail	10 June	8	24 May	31 May	18 June shell fragments		Possible predation?	
39	W	Grass	16 June	7	12 June	8 June	30 June		Probable hatch!	
41	W	Grass	17 June							
42	W	Grass	17 June	9	11 June	19 June	7 July	1		16-18
43	W	Grass		9	11 June	19 June	should have hatched	6 July	Avian	
45	W								Possibly mammalian	
46	W	Grass							Avian	
47	W	Grass	26 June	9	13 June	21 June	9 July	3		

/ G-Griswold Pond D-Durham K-Kensington B-Berlin
W-Wethersfield Meadows

* Estimated

x Days of incubation from the day following the deposition of the last egg

THE SORA

Arrival and Behavior

The first sora was observed on May 7, though some were probably present on the areas before that time. The earliest records as reported in Birds of Connecticut (1913) are May 25, May 16, and May 28. The behavior of the soras at this time was similar to that of the Virginia rail, though they were more secretive and were more difficult to observe.

Calls

The call most commonly heard during the spring was the so-called whinny described by Walkinshaw (1940) as "whee-hee-hee-hee heehee" increasing in rapidity as given. He also reported a plaintive "ter-oe" as being traceable to the sora. This call was described by Brewster (1902) as a sweet, plaintive "er-e," given with a rising inflection and suggesting one of the scatter calls of the quail. The alarm call was a sharp, high pitched "SKEEP," similar to that of the Virginia rail, though perhaps a rounder, more musical note. The fall call was undistinguishable, to the writer, from the fall call of the Virginia rail.

Nest Construction and Location

Nest construction, on the few nests from which data were available, was completed by May 21. There were some indications that nesting began earlier, but no definite information validating the supposition was found. The nests were constructed of material found close at hand. Many were built of cat-tail entirely, others were built of grass, bur-reed or coarse sedges. If finer materials were at hand, the nest might be lined. The construction was similar to that of the Virginia rail. The nest was a woven basket with the foundation on or within an inch or two of the substrate, generally built on a clump or mat of vegetation.

A canopy of surrounding vegetation was often woven above the nest. This canopy, rather than being pulled loosely over the nest as in the case of the Virginia rail, was frequently more closely knit and only two or three inches above the nest. The ramp, which sora nests rarely lacked, generally flared at the base, often being two inches at the nest and four inches at the water.

At Wethersfield Meadows, the swamp formed by the flood waters of the Connecticut River, an interesting situation occurred. The sora nests were built on pyres from 17 to 19 inches tall. These pyres were constructed of grasses and measured up to a foot at the base, narrowing to 4.5 x 5 inches at the nest bowl. Since these nests were not discovered until

Fig. 14. Sora nest built on a pyre composed of cat-tail and grass.

Fig. 15. Sora pyre composed of grass.

June 12, the formation of these pyres was not observed and the cause for their construction is not known. However it was thought that these nests were begun after the flood waters had receded and the water level in the swamp was low. Subsequent flooding caused the birds to build up the foundations which, in these cases, were 18 to 19 inches above the water level at incubation time. This supposition is supported by the Monthly Climatological Summary of Hartford Connecticut which shows a flooding of the Connecticut River from June 5 through June 10. The river stage of the Connecticut River was used as an index to the water depth in the river influenced swamps. The daily river stage exceeded 8.5 feet only once during the period from May 15 through June 4. On June 4 the river stage was 7.7 feet. June 5, a second flood, caused by heavy rains in the upper Connecticut River water shed, increased the river stage to 13.1 feet. The peak of this flood, 15.84 feet, was reached on June 6. By June 12 the river stage was again down to 6.8 feet. The actual amount of increase in the swamp is not known, but judging from the increase in the Connecticut River, some increase must have occurred. Such an increase could conceivably cause the birds to build up these foundations to prevent destruction of the nest by flooding.

The location of sora nests appeared to center in a more uniform habitat than did those of the Virginia rail. While the Virginia rail commonly used mixed coarse sedges as a

Fig. 16. Sora nest site.

nesting site, the soras nested more often in a solid cat-tail stand. Of 15 nests, six were built among cat-tails, two in Sparganium sp., two in coarse sedges and cat-tail, two in grass, one in cat-tail, grass and bur-reed, one on a hummock, and one on a hummock hidden in a clump of spirea. Two or three pair were heard among the hummocks during the nesting season, but the nests were not located. In general, the sora nests appeared to be in the wetter portions of the swamp, not infrequently found close to muskrat houses. At Griswold Pond where this was noted especially, the bog mat near the muskrat houses was exceedingly thin and gave way easily. No exact measurements of distances between the sora nests and muskrat houses were taken, but that distance at six nests, did not exceed 20 feet.

The distance between the two closest sora nests was found to be 165 feet. The nesting population of soras on the area upon which this observation was made was not sufficient to force the birds to use a minimum of territory. This distance may be used only as an indication of the toleration of soras to each other.

Two empty nests were found close to active and successful sora nests. The possibility that these empty nests were Virginia rail nests does exist, but the conditions on the area led the writer to believe that these were trial or practice sora nests. The distances from these nests to the nearest active nests were 22 feet and 16 feet.

There appears to be a great tolerance between sora and Virginia rail. The minimum distance found between nesting soras and Virginia rails was 15 feet.

Renesting

Evidence of renesting among the soras was scant. The destruction of most nests occurred late in the season and probably influenced this lack of renesting. It was considered that a nest destroyed early in the season had a greater chance of being rebuilt than one destroyed later. At Wethersfield Meadows the only good evidence for renesting was found. Here nest 9 with fragments of at least four eggs was found. This nest, judged to be a renest because of its proximity to nest 15, was built on an eight inch by 12 inch platform formed of bur-reed. This platform was exposed from above. Nest 16, which had no foundation, showed no sign of having contained eggs and was eight inches above the water. Nest 15 containing 11 eggs, which hatched between June 29 and July 3, measured five inches from the rim to the water and was well hidden by the heavy stand of grass which was then close to six feet tall. Nest 9 was 51.5 feet from nest 15 and 62 feet from nest 16. Nest 15 was 56 feet from nest 16.

Eggs

The eggs of the sora were a shiny olive buff, covered with blotches of maroon, brown and purple. The marking was not concentrated at one end, but was scattered irregularly over the entire surface. The size of the sora eggs, based on 117 measurements, varied from a maximum length of 34.3 mm to a minimum length of 28.7 mm and a maximum width of 23.9 mm to a minimum width of 20.9 mm. The average egg size was 31.9 mm x 22.9 mm.

Table 10. Variation of Egg Size Within A Clutch

Nest No.	Clutch Size	Max. Egg Length & Width in mm.	Min. Egg Length & Width in mm.	Max. Egg Width & Length in mm.	Min. Egg Width & Length in mm.
1	12	34.2x23.4	30.8x22.5	32.0x23.8	30.8x22.5
2	13	32.6x22.8	30.0x22.0	31.0x23.7	30.0x22.0
3	12	31.7x22.3	30.0x23.2	31.4x22.9	31.3x22.3
				31.5x22.9	31.7x22.3
5	11	32.3x22.8	30.0x22.6	30.6x23.1	30.3x22.0
6	15	33.4x22.3	30.7x22.2	32.3x22.8	31.5x22.1
				30.8x22.8	
7	14	31.5x22.7	29.7x22.8	29.7x22.8	31.1x22.1
				30.9x22.8	
8	10	32.5x23.4	31.3x23.4	32.2x23.5	31.5x22.9
10	--	34.3x22.2	30.8x20.9	32.5x22.7	30.8x20.9
12	--	33.2x23.0	31.4x22.8	32.5x23.4	32.8x22.3
13	8	33.0x23.2	30.3x22.9	31.9x23.5	31.3x21.9
15	11	32.0x23.4	28.7x22.4	32.0x23.4	28.7x22.4

The clutch size of the soras was high compared with the herons, red wings and even with the Virginia rail, but low in comparison to waterfowl. The average size of nine clutches,

Fig. 17. Sora nest. Note wide ramp and low canopy.

Fig. 18. Sora nest in cat-tail and coarse sedge showing chick and eggs.

considered to have been complete, was 11.77.

It has frequently been suggested that the great numbers of eggs in the sora clutch make it necessary for the birds to pile them in layers in order that they all might be incubated. Evidence to corroborate this supposition may be found, for, on occasion, an observer may find a nest with eggs heaped in two layers. However, in all but three cases (and the nests were checked at least twice a week from May 21 through June 11) the eggs were found in one layer. It was considered that if the bird were disturbed while in the act of turning the eggs, the eggs would be found in layers. This would give the impression that the clutch was so large that the birds could not possibly cover it were the eggs arranged in a single layer. It might also be added that a disorderly heap of eggs stacked in two layers gives the nest a much more full appearance than does a neat, orderly arrangement of the same number of eggs.

Incubation and Nesting Period

The incubation period according to Bent (1913), Roberts (1932) and Mousely (1937) was 14 days. Walkinshaw (1940) gave the records of six nests as 15 or 16, 16, 17, 16 possibly some to 19, 19 and 17 to 19 days respectively. For the six nests as a whole, he stated the incubation period to be from 16 to 19 days. The data on two nests, followed from the first

and seventh eggs respectively, indicated an incubation period from the laying of the last egg of 19 days. The fact that incubation may not be as regular during the last few days of hatching cannot be ignored when this figure is considered. It is strongly recommended that the eggs be numbered, indelibly, in order of laying so the succession of hatching can be followed.

The nesting period, from the time the first known egg was laid until the last known egg was hatched, was 44 days. The first was laid May 21, the last hatched July 3.

Hatching Period

Incubation has been stated by Walkinshaw (1940) as beginning several days before the laying of the last egg, and by Allen (1939) as beginning three or four days after the laying of the first egg. The length of the period during which the eggs of a single clutch hatch may bear this out. The hatching period for eight nests, observed in Connecticut during 1947, indicated an average hatching period of 10.5 days. This was far in excess of the hatching period of 12 soras in Michigan, which the figures of Walkinshaw (1940) showed to be 3.3 days.

Juveniles

The sora chick fresh from the egg was a homely youngster covered with wet, black down dusted with white flakes from

Table 11. Hatching Period of Sora Eggs

Nest No.	Dates of Hatching	Hatching Period Days	Nest No.	Dates of Hatching	Hatching Period Days
1	11-20 June	10	8	6-17 June	12
2	10-21 June	12	10	10-18 June*	9
3	5-13 June	9	15	29 June-3 July	5
6	8-24 June	17			
7	9-18 June*				

*Liberal estimates. These hatching periods may have been from one to three days longer.

the shell membrane. After the down had dried and the flakes had been worn off, he was scarcely more attractive. The down was dull black with no sheen, the head was practically bald, while the red cere on the mandible, emphasized by yellow chin whiskers, did more to make him grotesque than beautiful.

After a month had passed the head was olive brown with a black streak running through the crown; the rest of the crown and the nape of the neck were still in down. The auricular patch and the line above the eye were buff. The iris was olive brown. The bill was gray with some greenish yellow at the base and tip of the maxilla, giving it a blotched appearance. There was a possible trace of the cere at the base of the bill. The chin was white, with black down still present, and the white continued down the throat. The breast, neck

and sides of the face were fawn. The belly was white. The primaries, which were still in quill for the most part, were a drab brown at the tip. The secondaries were olive brown, while the scapulars and back were dusky black tipped with olive brown and spotted white. The back, then, had a flecked or even streaked appearance. The rump, which was still in down, was dusky black or drab gray. The tail feathers were black, tipped with olive brown. The undertail coverts were dark fawn; the quills could still be seen on that region. The legs were fawn or buff on the foreward part, becoming gray at the back. The sides of the body were gray, becoming light fawn, and one row of fawn feathers spotted with white was present in this region. The tarsus was gray with a greenish cast.

At six to eight weeks the color was similar, but the primaries were scarcely sheathed, and were square at the tip with a remnant of down still adhering. The bill was greenish brown above and yellow below. A trace of black could be seen at the lores. The general impression of the sora of this age class, was that of a plump, dark bird flecked with white.

On September 17 the lores were beginning to show black more distinctly, and a bluish tinge was evident on the breast. The chin was gray, the throat white. The cheeks and sides of the neck had become blue gray, replacing the juvenile buff color. The forehead was slate, gray blue. The iris was rufous brown. The bill and tarsus were greenish. Unopened quills, indicating molt, were evident on the back.

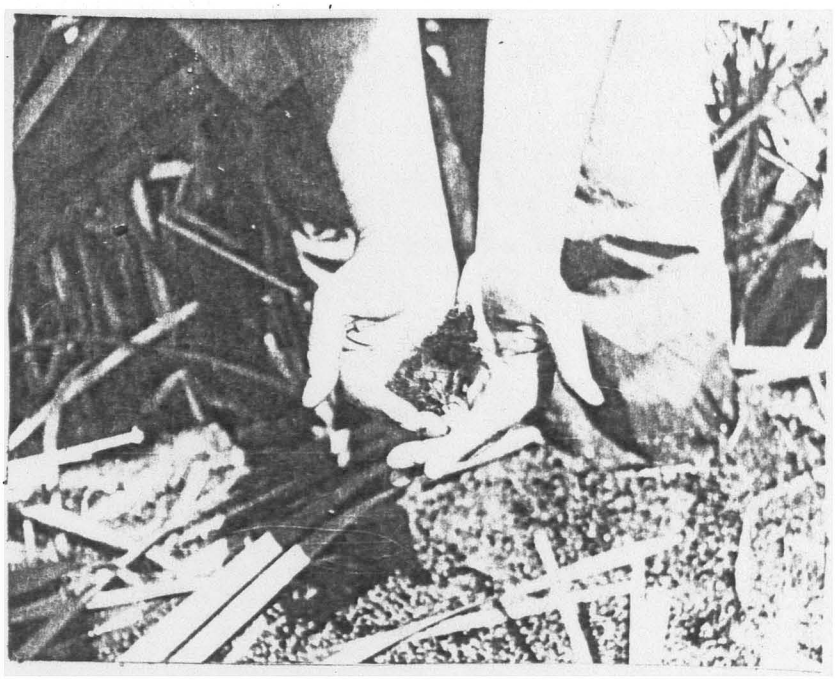

Fig. 19. Sora chicks. The chick toward the front was newly hatched. The other was approximately an hour old.

Predation

Of 15 nests, six were destroyed by predators. Four of these cases occurred at Wethersfield Meadows; only two of the sora nests found on that locality were successful. The shell fragments indicated avian predation and the yellow billed cuckoo, which was nesting on the area, was judged to have been responsible. Remnants of one nest, which evidently had been destroyed early in the nesting season, were found at Cromwell Meadows. One nest, of seven at Griswold Pond, was destroyed shortly after hatching had begun. Three of the eleven eggs were hatched successfully. The nest was concealed in a spirea bush which was located in an open pool. Toward mid-June the pool dried leaving the area surrounded by knee deep mud. The adults were exposed as they entered and left the nest, which may have aided this predator in finding the site. The predator was thought to have been avian, possibly crow.

Behavior

The sora proved to be more difficult to observe than were the Virginia rail under similar circumstances. Only two adult soras showed great concern when the nest was approached and then only during the latter part of the incubation period after one or two chicks had hatched. Both of

those birds wandered through the vegetation giving the alarm note, but remained a good six feet from the observer. A member of the Hartford Bird Study Club, however, reported a sora which literally had to be thrown off the nest before any observations could be made.

An interesting occurrence at nest 3 might well be entered here. On discovery this nest contained eleven eggs. Another egg lay in the water about one foot from the nest. The egg was marked and replaced in the nest. On two visits, within eight days, this egg was found in the water between one and three feet from the nest. The third time, as the egg was being freshly numbered, the shell cracked showing it to be rotten.

The behavior of the sora chicks was similar to that of the Virginia rail chicks. At the warning calls of the adults the young ones hid under the vegetation that lay tangled over the surface of the water. On two occasions the tracing of a frenzied call, similar to that given by a nestful of hungry young birds, revealed a sora chick caught in a clump of pond weed. After one week, however, the sora chicks disappeared. Alarm notes given in the vicinity of a nest site, judged to be those of a sora, were heard on numerous occasions, but no amount of searching revealed immature soras. Some birds in their fourth or fifth week were collected in the trap as soon as it was placed on the area, showing that they had probably been on the area during that three week period, but had remained hidden.

Table 12. Summary of Data on Sora Nesting Conditions

Nest No.	Study Area/	Cover Type at Nest Site	Date Found	Clutch Size	Date First Egg Hatched	Date Last Egg Hatched	Days Hatching Period	Predation	Infertile Eggs	Incubation
1	G	Cat-tail	22 May	12	11 June	20 June	10			19
2	G	Cat-tail	27 May	13	10 June	21 June	12			19
3	G	Cat-tail coarse sedge	2 June	12	5 June	13 June	9		1	
5	G	Hummock Spirea	4 June	11	15 June			Avian		
6	G	Cat-tail Coarse sedge	4 June	15	8 June	24 June	17		1	
7	G	Cat-tail	4 June	14	9 June	18 June	10		1	
8	G	Cat-tail	7 June	12+	6 June	17 June	12			
9	W	Bur-reed	9 June	4+				Avian		
10	W	Cat-tail	11 June	6+	10 June	18 June	9			
11	W	Bur-reed	12 June	8+				Avian		
12	W	Grass	12 June					Avian		
13	W	Grass	13 June	8+				Avian		
14	W	Cat-tail								
15	W	Cat-tail Grass Bur-reed	26 June	11	29 June	3 July	5			
18	C	Bur-reed	20 June					Avian		

/ G-Griswold Pond W-Wethersfield Meadows C-Cromwell
* Number of days of incubation after the last egg was laid

HUNTING

In Connecticut most of the rail hunting is done along the southern part of the Connecticut River in the wild rice beds between Saybrook and Middletown. Most of the hunting is done in the vicinity of Essex. The rice grows to a height of six or seven feet affording excellent cover and good food. The rails, which probably migrate down the Connecticut River from the upper New England states, stop off at these rice beds and (Forbush, 1925) stay until the food supply is diminished or until bad weather drives them along. It is thought that most of the birds present in these rice beds during the fall are not birds raised in Connecticut.

The rice beds are difficult to hunt on foot, even at low tide. At high tide, when the birds are more prone to fly, many sections are too deep to hunt on foot. Therefore, to hunt the rice beds with any degree of success, the services of a pusher are required. The pusher uses a light, flat bottomed boat of 12 to 14 feet which draws two or three inches of water. In the bow a stool or chair is nailed. The pusher stands in the stern and, by means of a long pole, pushes the boat through the rice. The birds are shot, by the hunter who is sitting on the stool, as they rise before the boat.

Generally the first time a bird was disturbed it flew no more than five to ten feet, rising two or three feet into

the air at the highest point. This was more of a jump than a flight. At the second disturbance the bird would fly one or two hundred yards or more. These observations were made from a canoe rather than from a push boat, the canoe being slower and more difficult to handle may have affected the behavior of the birds.

It is the opinion of this writer that the prowess of these birds in flight is greatly underestimated. It is true that rail appear to have a labored flight, especially as mentioned above, when first disturbed. However, the oft-repeated query as to how the rail with its weak flight can ever carry on an extensive migration is, according to the writer, highly overdone. The flight of the rail is swift as compared to what the observer, having read of the weak, labored flight, would expect. It is somewhat similar to that of Wilson's snipe, though slightly slower and normally in a direct line. The wing stroke of the sora appeared to be alternate as is the stroke of the chimney swift. Since the take off is so sudden and the flight so abrupt, the validity of this statement has not been checked to the satisfaction of the writer. However, brief glimpses of soras in flight have given the impression of alternate wing motion. While in the air the bird generally looks downward, glancing from side to side, almost as though deciding upon a suitable place to alight. The take off can occur from a standing position and is initiated by a jump. Incidentally two birds tested in a bathtub

were found to be unable to take off when they could not touch bottom. One of these birds showed definite signs of sinking after three minutes of swimming and futile wing flapping. Both birds swam to the back of the tub and flapped their wings against the porcelain.

The rail can escape most dangers just as well and with less effort by skulking in its habitat, than by springing into the air and flying to another site. When a real need arises, as at migration time or successive disturbances by an intruder, the rail can and does exert itself in a strong, sure, smooth, though not rapid, flight. This does not mean to imply that the rail soars through the air at a great height, for this writer has not seen one fly more than twenty feet above the vegetation. It is meant to clarify and modify the former statements of a weak, wobbly, labored flight which makes one wonder how the bird manages to stay in the air at all.

The hunting is done at high tide, a period of one and one half to two hours marking the extent of hunting time per tide. According to the pushers the best hunting occurred during the September equinoctial tides, when the wind, carrying rain, is from the east.

Hunting on the breeding grounds is not as extensive as the hunting done on the rice beds. The hunting time per bird is considerably higher, and the effort required on the part of the hunter is greater, for the birds are particularly hard to flush in late summer and early fall.

The writer is not yet equipped to defend or protest the present limit of fifteen rails and gallinules exclusive of soras and twenty-five soras in addition. It is believed, though, that the limited numbers of hunters (probably two or three hundred at the most) will not deplete the rails immediately. The high bag limit may actually keep the kill rate down since, in recent years the limit has been difficult to approach, thus the incentive to make the limit is lessened. As long as some birds continue to haunt the more inaccessible swamps, such as that at Cromwell, there will continue to be a seed stock.

The season from September 1 through November 30, though it appears long, is actually, in hunting time, rather short. The hunting time is rarely more than four hours per day and is highly dependent on the weather and tidal conditions. There are perhaps 546 hours or about 23 days of hunting if optimum conditions prevail.

The immature birds are able to fly from the third week in July in most cases. The adult molt is nearly complete by the first of September. The fact that the birds are on the rice fields at the time of hunting attests to their ability to take care of themselves.

EVALUATION OF SWAMP TYPES

Griswold Pond with a study area of 6 acres, held 15 pair of birds: nine pair of Virginia rail and six pair of soras. The area was predominantly cat-tail, with a heavy understory of assorted sedges and rushes which bore a good achene crop. The bog mat was not firm and the water depth below the bog was between three and four feet, though the water level as far as rail were concerned did not exceed five inches. Two sections of pure cat-tail, i.e., those with a heavy stand of cat-tail supporting little in the way of an understory, revealed no birds. Narrow leaved cat-tail appeared to be less productive of rail than was broad leaved cat-tail.

Three other cat-tail swamps, not study areas, which lacked an understory were apparently barren of rail. This gives an indication of the value of such an understory to rail.

Durham Meadows, with a study area of 5.5 acres, held an estimated nine pair of birds: eight Virginia rail and one sora. Three active nests, four brood areas and two nests containing shell fragments were the basis for the estimate. This area was predominantly hummock sedge, with a few limited cat-tail sections. The water depth remained fairly constant at four to six inches, though the muddy bottom increased this to a depth of 18 to 24 inches, an increase which would not be apparent to the rail.

Wethersfield Meadows, with a study area of five acres, held an estimated nine pair of birds: five pair of Virginia rail and four pair of soras. This area was predominantly grass with a large area of bur-reed and several patches of cat-tail. The water level receded throughout the summer, but held an average of seven inches through the middle of August. Portions of the swamp remained at ten to 12 inches, while larger sections ranged from zero to ten inches. The bottom of this swamp was relatively firm. Predation was heavy since of 11 nesting attempts of nine pair of birds only five were known to have been successful. Three of these were Virginia rail, two were soras.

Berlin, with a study area of three acres, held an estimated three pair of Virginia rail, based on one nest and two sections from which birds were heard. This area was predominantly hummock sedges with a water level of three to four inches. The bottom was firm.

Cromwell Meadows, with a study area of six acres, held an estimated two pair of Virginia rail as based on calling birds. The area was flooded during the early part of the nesting season. The bottom was muddy giving a mud-water depth of ten to 20 inches. An interesting occurrence was noted during the hunting season. This swamp is separated by a peninsula. The Sebethe River, which is heavily polluted, flows through a major portion of the swamp. Sheltered from the main flow of the river by the peninsula, the smaller

section receives less of the direct effects of the polluted water. The sheltered area revealed more birds than did the thoroughly polluted portion. In September, during a two-hour search through the latter part, no birds were heard, while close to 15 birds were heard at a single gunshot fired over the former section. The portion through which the river flows supports cover similar to that of the sheltered cove and in the past has held many birds.

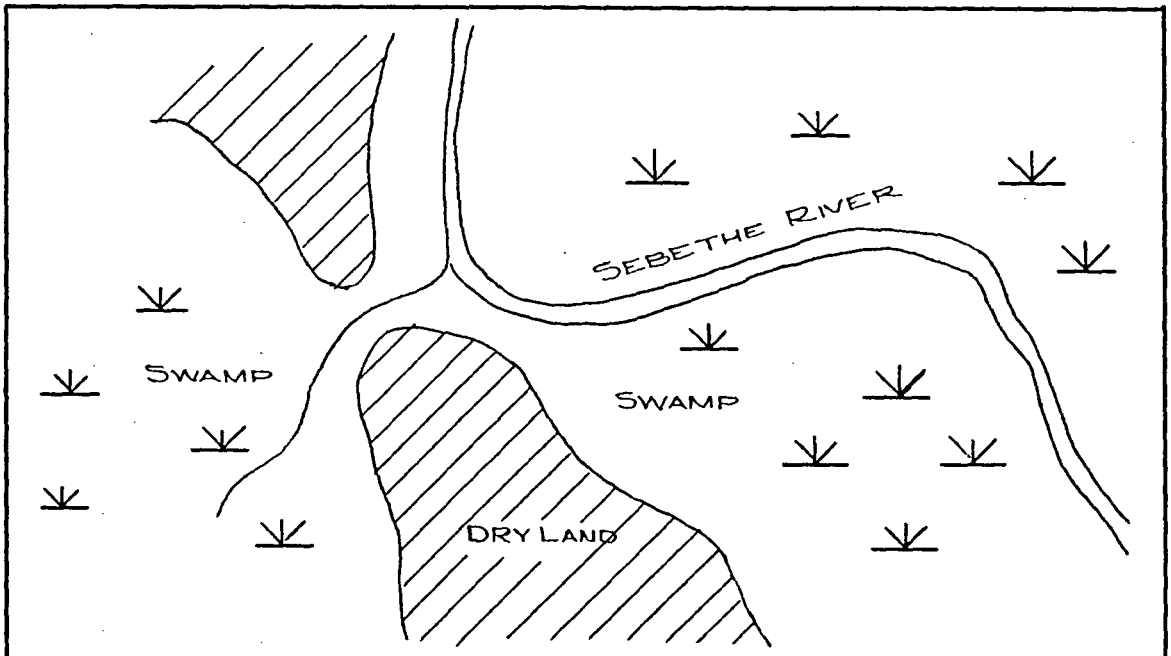

FIG. 20 SKETCH MAP OF THE SOUTHERN TIP OF CROMWELL MEADOWS

The Pequaback, a polluted area of 40 acres was covered by canoe and foot during the investigation. In addition, two 2.5 acre portions were carefully examined through the latter part of April, May and early June. No rail were found on the area, although birds commonly nesting near rail were present.

From this summary the optimum condition for rail was judged to be a cat-tail swamp with many grasses, sedges and rushes forming an understory. This provides both food and cover. Cat-tail swamps lacking the understory were found to be barren of rail. Muskrat activity appeared to be favorable, especially to the sora which frequently nested near the muskrat houses. The instability of the bog mat in this situation, as well as the opening created, probably influenced this preference for muskrat houses.

A shallow water depth, from one to ten inches, in conjunction with a muddy, unstable bottom appeared to be favored.

Next in preference to cat-tails came the hummock sedges, those sedge swamps with a muddy bottom were more heavily used.

Effect of Pollution

Pollution appeared to have an adverse effect on the rail population within a swamp. Use of polluted areas, during both the nesting and hunting seasons, was limited as compared to similar unpolluted swamps. Other birds as the redwing, black duck, bluewinged teal (Anas discors), swamp sparrow, American bittern, American egret (Casmerodius albus egretta), great blue heron (Ardea herodias), and black crowned night heron (Nycticorax nycticorax hoactli) did not appear to be affected as greatly by pollution. This may be

due to the fact that those birds do not limit themselves to a more or less restricted portion of a single swamp, but may fly back and forth between nesting and feeding areas. The rail, which appear to remain in the breeding swamp for a considerable portion of the summer, perhaps have difficulty in finding enough suitable food in a polluted area and thus restrict themselves to swamps where conditions are closer to the optimum.

Four districts of Connecticut were examined in order that an indication of the number of swamps available for breeding birds might be obtained. The districts covered included portions of the Eastern and Western Highlands, the central Lowland, the coast and the territory surrounding the wild rice beds.

The type of swamp land most heavily used by rail was described to the Game Wardens of those districts. The Wardens were requested to point the swamps, in their districts, which could meet the qualifications.

A survey of Windham County in the Eastern Highland revealed seven of 12 swamps as having possibilities for rail breeding. Three of these were listed as good, two as fair, and two were considered as potential areas if succession proceeded favorably.

This part of Connecticut is not heavily populated and contains no large cities. The destruction of these swamps is by no means as evident as the destruction of swamps in the

southern half of the state.

Ten swamps of the Western Highland were observed. Of these ten, only three were considered as possible rail breeding areas. None were considered to have optimum conditions. Most of those of northern Fairfield County, were considered to be too brushy for rail.

Only two swamps, of ten observed in the central Lowland, were considered as suitable for rail. Both of those swamps were rated as good areas. It should not be forgotten that all six of the study areas were found in this part of the state. The central Lowland is probably the outstanding section for rail breeding areas in Connecticut.

The coastal and inland swamps of Fairfield County were also surveyed. Of 30 swamps visited, 15 were considered as possible rail areas. Five of these were rated as good, five fair, two possible, and three as suitable if water were held on them until mid-August. Four salt marshes which might be suitable to Clapper rail were also found.

A survey of the country surrounding the wild rice beds of the lower Connecticut River, revealed very few possible rail breeding areas. Of ten swamps observed, two appeared to be suitable for rail nesting. They were both rated as fair. Many swamps along the Connecticut River had good conditions in mid-August, but spring flooding probably prevented their use by nesting rail.

A complete investigation of each section of the state was not attempted. Only those swamps considered to have some value to rail were visited. Of the 72 swamps thought to fit the description of rail breeding habitat, only 29 were considered as possible areas.

Probably the most serious limitation of the survey for breeding areas was that all conditions under which rail will nest are not known. The tolerance of rail to brushy areas, especially, is unknown. Another difficulty lay in giving an adequate, concise description of the conditions preferred by rail, to the wardens. Despite these limitations the figures for the number of rail breeding swamps should give an indication of the number of swamps available in the state.

A summary of this survey shows possible rail swamps to be few and of poor quality. The swamps of the central Lowland have, by far, the best conditions for rail breeding. Fairfield County is a poor second, while few suitable swamps were found in the other districts examined.

DISCUSSION OF KILL RECORD AND SWAMP CONDITIONS

An examination of the kill record of the Connecticut State Board of Fisheries and Game for the years 1923-1944 reveals 1923 and 1930 through 1933 as having the highest report of birds taken. Following the slump in 1924 some measure of recovery is seen in 1925-1927; and some increase is shown from 1940-1942 following the severe drop from 1933. Since 1933, however, the number of birds reported as taken has shown a downward trend.

Table 13. Kill Record of the Connecticut State Board of Fisheries and Game 1923 through 1944

Year	Reported Take	Percentage Reporting
1944	1007	33
1943	608	47
1942	925	40
1941	1052	40
1940	987	51
1939	627	49
1938	571	38
1937	444	45
1936	1589	59
1935	2439	56
1934	2864	71
1933	3966	68
1932	5872	62
1931	3627	56
1930	4551	45
1929	2694	52
1928	1665	49
1927	2470	53
1926	2358	69
1925	2039	68
1924	1374	58
1923	4722	32

These reported kill figures have been used as an index to the production and success of birds to the hunting season. It is assumed that the number of birds reported as taken during a certain year is in proportion with number of birds surviving until the hunting season for that year. If this is correct, the success of these birds has decreased considerably during the last ten years.

The recovery potential has been obtained by dividing the reported take of each year by the reported take of the preceding year. The assumption that the reported take is indicative of the number of birds surviving until the hunting season is maintained here also. The recovery potential indicates that the birds may increase as much as 115% from one year to the next, yet the number of birds reported in the last ten years remains at a fairly constant low level.

It is realized that there are many factors bearing on the number of birds reported as taken which would not affect the survival of the birds. Among these are general economic conditions and weather conditions, which would control the number of hunters in the field. However, it is believed that good rail habitat is being depleted seriously each year.

Swampland has been considered as wasteland and now, as the pressure from large towns and cities is increasing, swamps are being filled to make airports, housing projects and other necessities of growing cities. A drive along any main route in Connecticut will show approximately four out of five of

the swamps, which could be of use to rail, in the process of being filled. Other swamps, particularly those bordering Long Island Sound, have been mosquito ditched. This draining apparently changes the water level, bottom conditions and vegetative types enough to limit the use of these marshes to few rail only.

On the other hand are the lakes which should be proceeding to a stage of emergent vegetation. These are held back by dredging and cutting to provide better recreational facilities as well as to increase their scenic value. In Fairfield County five such instances were noted. Many of those were small ponds which if left untouched would have produced one or two acre rail swamps. Dredging, draining and damming have cut this area in half, making the swamps so small or breaking them up in such a manner that they were of no use to rail.

Man is not alone in the movement against the swamp, for natural forces are constantly at work filling in and over growing swamps. Admittedly this process is slow, but the factors limiting and speeding the destruction of swamps exceed the forces creating new swamp areas. This slow limitation or restriction of swamps, in addition to the fact that rail can use only a certain stage of swamp development, may seriously limit the numbers of birds in the future.

SUMMARY

This investigation of Virginia rail and sora life history and habitat was conducted on six different swamp types.

The following statements summarize the findings for the Virginia rail.

1. The major part of the migration arrived about the first week in May, though the first arrivals were observed April 20. The rails were more easily observed in spring than in summer and fall.

2. The calls were "cut cut cutta cut" early in the spring, a pig-like grunt during the nesting season, a sharp harsh alarm note, and a sharp "KEEP" during the fall.

3. Nest construction, among the Virginia rails occurred largely during the second and third weeks of May. The earliest estimated date for a complete clutch was May 7. The latest date for a completed clutch was June 13. The nest was composed of materials found near the nest site. Most nests had canopies and ramps. The canopies were generally loosely woven of surrounding vegetation. The ramps were narrow and generally of uniform width from the rim to the water.

4. The most heavily used vegetation for nesting sites was cat-tail and coarse sedge, though hummock sedge and reed

canary grass were also used to some extent. A water depth of three to seven inches with a muddy bottom was probably the optimum. The Virginia rail generally nested in the less wet portions of the swamp.

5. Many empty nests, considered to be practice or trial nests were found. These nests were not found closer than 43 feet from the nearest active nest.

6. The minimum distance for active nests was found to be 132 feet. Some evidence of renesting was found. The minimum distance of renests from active nests was 25 feet, the maximum 62 feet. There was no evidence of second broods.

7. The eggs were white heavily speckled with reddish brown and purple at the larger end. The average egg of 116 measured was 31.49 mm by 23.9 mm.

8. The clutch size ranged from seven to eleven eggs with an average of 9.66 per clutch.

9. The number of days of incubation following the laying of the last egg was 18. Generally one egg hatched a day later than the rest in the clutch.

10. Only six eggs of 139 failed to hatch, thus egg success was 95.7 percent. Five of those failing to hatch were found in renests. Nesting success was 68 percent.

11. The nesting period covered 63 days on all the study areas.

12. Birds disturbed from the nest at incubation time called shrilly and attempted to distract or frighten the

intruder by spreading the wings and by other treatening poses. An occasional bird protected the nest by direct attack.

13. The chicks were downy and received the first trace of feathers at the third week. At six to seven weeks the birds were able to fly limited distances. In September the juveniles were beginning to assume adult plummage.

14. Evidence of adult molt was seen during the last week of July. All flight feathers were lost at that time. This molt was almost complete by September 1. A molting juvenile was taken September 10.

15. Nine of the twenty-five nests located were destroyed. Five of those cases occurred at Wethersfield Meadows. Avian predation was judged to be the greatest cause of destruction. Nesting success was 64%.

The following statements summarize the findings for the sora.

16. The soras were not observed until May 7 and their migration may occur slightly later than that of the Virginia rail.

17. The most common spring call was the whinny. Another spring and summer call was the plaintive "er-e". The alarm call was similar to that of the Virginia rail. The fall call was indistinguishable from that of the Virginia rail.

18. Nest construction was completed by May 21, or possibly earlier. The nest was composed of cat-tail, coarse

sedge, hummock sedges and generally had a canopy and ramp. The canopy was generally closely knit above the nest. The ramp was wider than that of most Virginia rail nests and generally flared at the base. The sora nests were built in the wetter portions of the swamp, not infrequently close to a muskrat house. Most nests were built in cat-tail though coarse sedges, grasses and bur-reed were utilized somewhat.

19. Some evidence of renesting was found. One renest was found 62 feet from a destroyed nest. There was no evidence of second broods.

20. The eggs were olive buff blotched with maroon, purple and brown. The average egg size was 31.9 mm x 22.9 mm.

21. The clutch size ranged from eight to 15 with 11.77 as the average.

22. The nesting period was 44 days. The first egg was laid May 21, the last hatched July 3. The average hatching period of individual nests was 10.5 days.

23. The sora chick was downy with a red sere and yellow chin whiskers which made it easily distinguishable from Virginia chicks. The birds were almost completely feathered by their sixth week. By mid-September they were beginning to resemble the adults but were still considerably more yellow.

24. Predation of sora nests was most severe at Wethersfield Meadows. Four of the five cases of nest destruction

occurred there. Nesting success was 69 percent.

The following statements summarize the last sections of this thesis:

25. Hunting is done on the lower Connecticut River between Saybrook and Middletown. The birds are hunted by boat and at high tide.

26. Rail breeding area, as judged by the survey conducted, is limited. Few suitable breeding areas were located in the state; the best of those found were located in the central lowland. Of 72 swamps investigated only 29 were considered as possible breeding areas.

LITERATURE CITED

Allen, Arthur A.
1939. The Golden Plover and Other Birds.
The Comstock Publishing Co., Ithaca, N. Y.

American Ornithologists' Union
1931. Check-list of North American Birds. 4th ed.
American Ornithologists' Union, Lancaster, Pa.

Bent, Arthur Cleveland
1926. Life Histories of North American Marsh Birds.
U. S. National Museum Bulletin 135.

Brewster, William
1902. Voices of a New England Marsh.
Bird Lore 4: 43-56.

Chapman, Frank M.
1932. Birds of Eastern North America.
D. Appleton and Co., New York.

Ditmars, Raymond Lee
1907. The Reptile Book.
Doubleday, Page and Company, New York.

Forbush, Edward Howard.
1925. Birds of Massachusetts. Part I.
J.S. Cushing Co.-Berwick and Smith Co., Norwood, Mass.

Gray, Asa
1908. New Manual of Botany. 7th ed.
American Book Company, New York.

Mouseley, H.
1937. A Study of Virginia and Sora Rails at Their Nests.
Wilson Bulletin 49: 80-84.
1940. Further Notes on the Nesting Habits of the Virginia Rail.
Wilson Bulletin 52: 87-90.

Peterson, Roger Tory
1947. A Field Guide to the Birds.
Houghton Mifflin Co., Boston, Mass.

Roberts, Thomas S.
1932. Birds of Minnesota.
University of Minnesota Press, Minneapolis.

Sage, John Hall. Bishop Louis Bennett
1913. Birds of Connecticut. Bul. 20.
Connecticut State Geological and Natural History Survey.

U. S. Dept. Commerce.
1947. Monthly Climatological Summary.
Hartford, Conn. Municipal Airport, April-June.

Walkinshaw, Lawrence H.
1937. The Virginia Rail in Michigan.
The Auk 54: 464-475.
1940. Summer Life of the Sora Rail.
The Auk 57: 153-168.

Wood, H. B.
1937. Incubation period of the Virginia Rail.
The Auk 54: 535-536.

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